

## ***Bryoria hengduanensis* (Lichenized Ascomycota, Parmeliaceae), a New Species from Southern China**

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*Bryoria hengduanensis* L. S. Wang & H. Harada sp. nov., from Yunnan and Sichuan in southern China, is characterized by a pendant thallus, pseudocyphellae spiraling around the branches, medullary hyphae, and usnic and fumarprotocetraric acids. The closely related *B. pseudocapillaris* Brodo & D. Hawksw. and *B. spiralifera* Brodo & D. Hawksw. have white pseudocyphellae, and *B. tortuosa* Brodo & D. L. Hawksw. is sorediate. The new species also differs from all three of these North American species by chemistry.

Key words: *Alectoria*, *Bryoria*, chemistry, China, lichenized Ascomycota, new species, *Oropogon*, Sichuan, *Sulcaria*, taxonomy, Yunnan

Alectorioid lichens are characterized by a fruticose thallus, terete branches, a distinct cortical layer, an arachnoid medulla without a central axis, a trebouxoid photobiont, and lecanorine apothecia. They are widely distributed in the world and are represented in East Asia by *Alectoria* Ach. in Luyken, *Bryoria* Brodo & D. Hawksw., *Bryocaulon* Kärnef., *Oropogon* Th. Fr., *Pseudephebe* M. Choisy, and *Sulcaria* (Motyka) Bystrek. Among them, the most species-rich genus is *Bryoria*, which seems to have a center of distribution in the Himalayan region. Many species are known there, including 14 from India and Nepal in the south (Awasthi & Awasthi 1985), and in the east, 13 of the 18 species known from all of China come from Yunnan (Wang & Chen 1994, Wu & Wang 1992). In this paper, we describe a new and distinctive species of *Bryoria*.

### **Materials and Methods**

The description of the external morphology is based on air-dried material observed under a dissecting microscope. For anatomical description, sections made with a razor blade were mounted in lactophenol cotton blue (LPCB), and GAW (glycerol: ethanol: water=1: 1: 1) preparations were used for the color descriptions. The specimens used in this study are deposited in the Cryptogamic Herbarium of the Kunming Institute of Botany, Academia Sinica (KUN-L), with some duplicates in the Natural History Museum and Institute, Chiba (CBM), and Duke University (DUKE).

Chemical analyses were made by thin-layer chromatography (TLC) and high-performance liquid chromatography (HPLC). TLC was by a standard-

ized method (Culberson *et al.* 1981) using three solvent systems and controls of atranorin and norstictic acid. HPLC used a Beckman ODS column (4.6 × 250 mm; 5µm) and a gradient formed by mixing methanol : water : o-phosphoric acid (30 : 70 : 1) (Solvent 1) with methanol. The 40-min gradient from 80 % to 16 % Solvent 1 was followed by 15 min at 16 % Solvent 1. Detection was at 270 nm. Identifications were based on TLC and HPLC comparisons with pure samples and with extracts from specimens serving as authentic sources of specific compounds. Specimens showing unexpected mixtures of compounds were retested using single strands separated microscopically and analyzed by HPLC.

### Taxonomy

***Bryoria hengduanensis*** L. S. Wang & H. Harada, **sp. nov.** (Figs. 1 & 2)

Thallus fruticosus, capilliformis, pendens, 3-5(-15) cm longus, ramis aniso-dichotomiter fastigiatis basin versus, iso-dichotomiter fastigiatis apicem versus, pallido-brunneis, sed denigratis basin versus, nitidis, ramulis spinulosis lateralibus communibus, pseudocyphellis elongatis in spiram contortis, soralis desititutus, hyphis medullois rasilibus, acidum usnicum et acidum fumarprotocetraricum continens.

*Type:* CHINA. Yunnan Prov., Zhongdian Co., Tian-chi Lake, 3900 m elev., on *Abies georgei*, Aug. 1993, Wang Li-song 93-13673 (KUN-L 13927, holotypus; CMB-FL-13390, isotypus).

*Etymology:* The epithet "*hengduanensis*" refers to the type locality, the Hengduan Mountains in Sichuan, Yunnan and Xizang, east of the Great Himalaya Range.

*External Morphology:* Thallus fruticose, hair-like, pendant, 3-5(-15) cm long, anisotomic-dichotomously branched towards the base, becoming isotomic-dichotomously branched towards the apices,

with angles between dichotomies obtuse and rounded towards the base (usually 80°-90°) and acute towards the apices (c.30°-50°); branches cylindrical, rather even in diameter; main branches c.0.2-0.3mm diam., generally pale brown, black only in the basal parts, shiny; lateral spinulose branches common, usually up to 1-5mm long, not constricted at the base, usually concolorous with the main branches, sometimes becoming dark brown towards the apices; true lateral spinules absent; pseudocyphellae linear, twisting in long spirals, slightly concave to fissured, concolorous with the thallus or dark brown; soralia absent. Apothecia and pycnidia absent.

*Anatomy:* Middle parts of the main branches in cross-section entirely circular, 250-270µm in diameter; cortex 30-50µm thick, one-layered, colorless throughout, rough on the surface, sometimes discontinuous due to sulcae; medullary hyphae not ornamented, 4-5µm diam.

*Chemistry:* Cortex P+ orange, K<sup>-</sup>, C<sup>-</sup>, KC<sup>-</sup>; medulla P+ yellow (or -), K+ pale yellow, C<sup>-</sup>, KC<sup>-</sup>. Usnic acid, fumarprotocetraric acid, trace protocetraric acid, trace confumarprotocetraric acid; R<sub>f</sub> and R<sub>t</sub> values given in Table 1.

In herbarium specimens, the closely intertwined hair-like thalli (strands) may belong to more than two species: *Bryoria hengduanensis*, *Bryoria* sp., and *Usnea longissima*. *Usnea longissima* is easily distinguished by its color from the present new species, but it is very difficult to remove the similar brownish *Bryoria* sp., which contains usnic and barbatolic acid with or without gyrophoric acid. Thus, if samples taken for TLC analysis contain several strands, it is possible for the result to give an additive chemistry equal to both *Bryoria* species combined. The resultant TLC and HPLC analyses are extremely complex, including all the compounds normally associated with this species plus those associated with barbatolic acid (e.g., alectorialic acid, barbatolin, alectorialin, and the hydrolysis products of these compounds) and those associated with gyrophoric acid (lecanoric acid and a trace of

orsellinic acid). The analysis of two multi-strand samples of *Wang 93-13675* (analysis no. 11756), both gave usnic (US), fumarprotocetraric (FU) and barbatolic (BA) acids. The analysis of one multi-strand sample of *Wang 00-19999* (analysis no. 11956) gave only US and FU. But when two single-strand samples were analyzed, one gave US plus FU

and the other gave US plus BA. A recheck of two specimens (analysis nos. 11756 and 11956) under the dissecting microscope showed that both were mixtures of *B. hengduanensis* and *Bryoria* sp. In the analysis of single-strand samples, *B. hengduanensis* contained US and FU (Table 2) and *Bryoria* sp. contained US and BA.

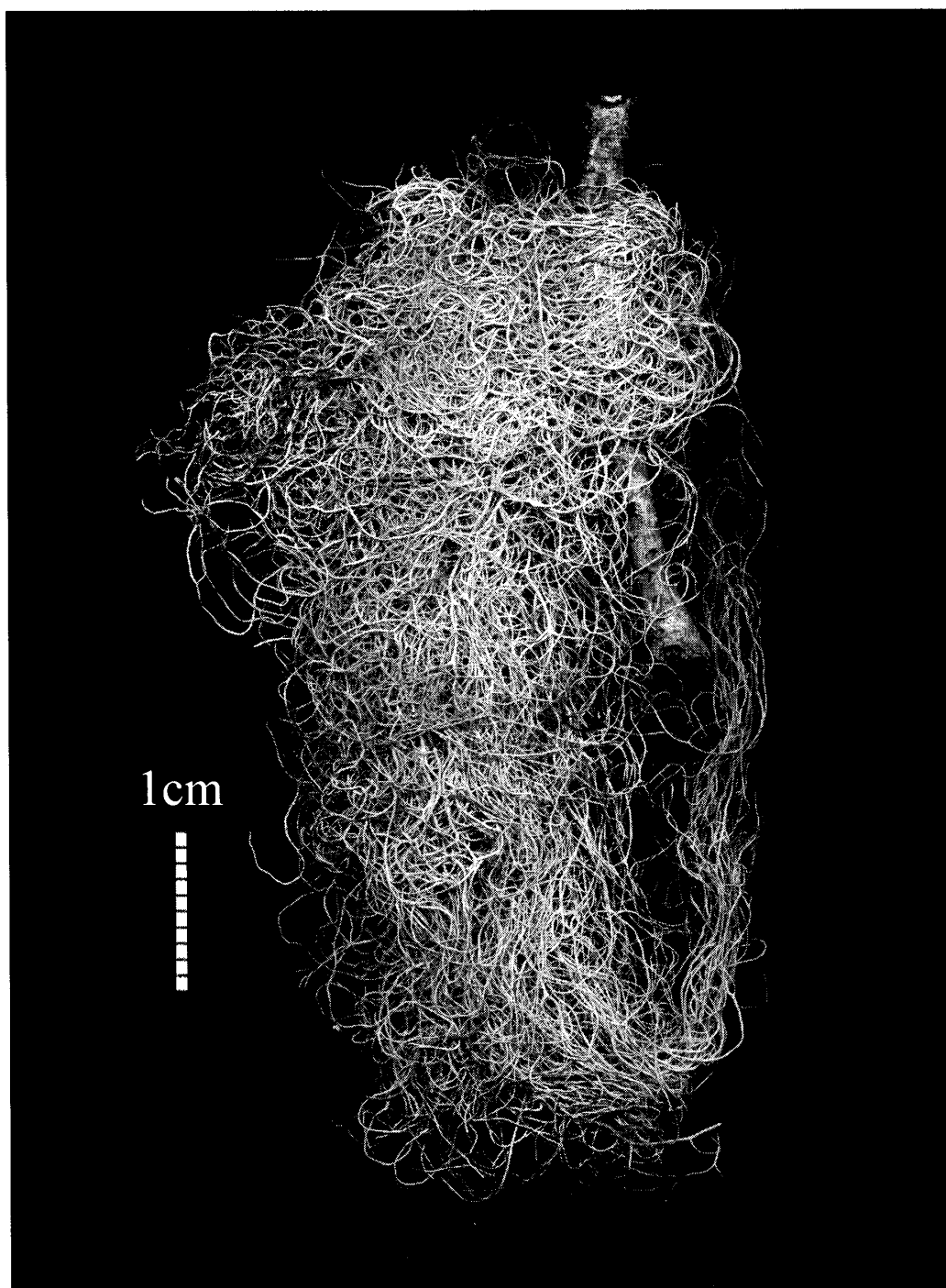


FIG. 1. Habit of *Bryoria hengduanensis*. (Part of holotype, air-dried material)

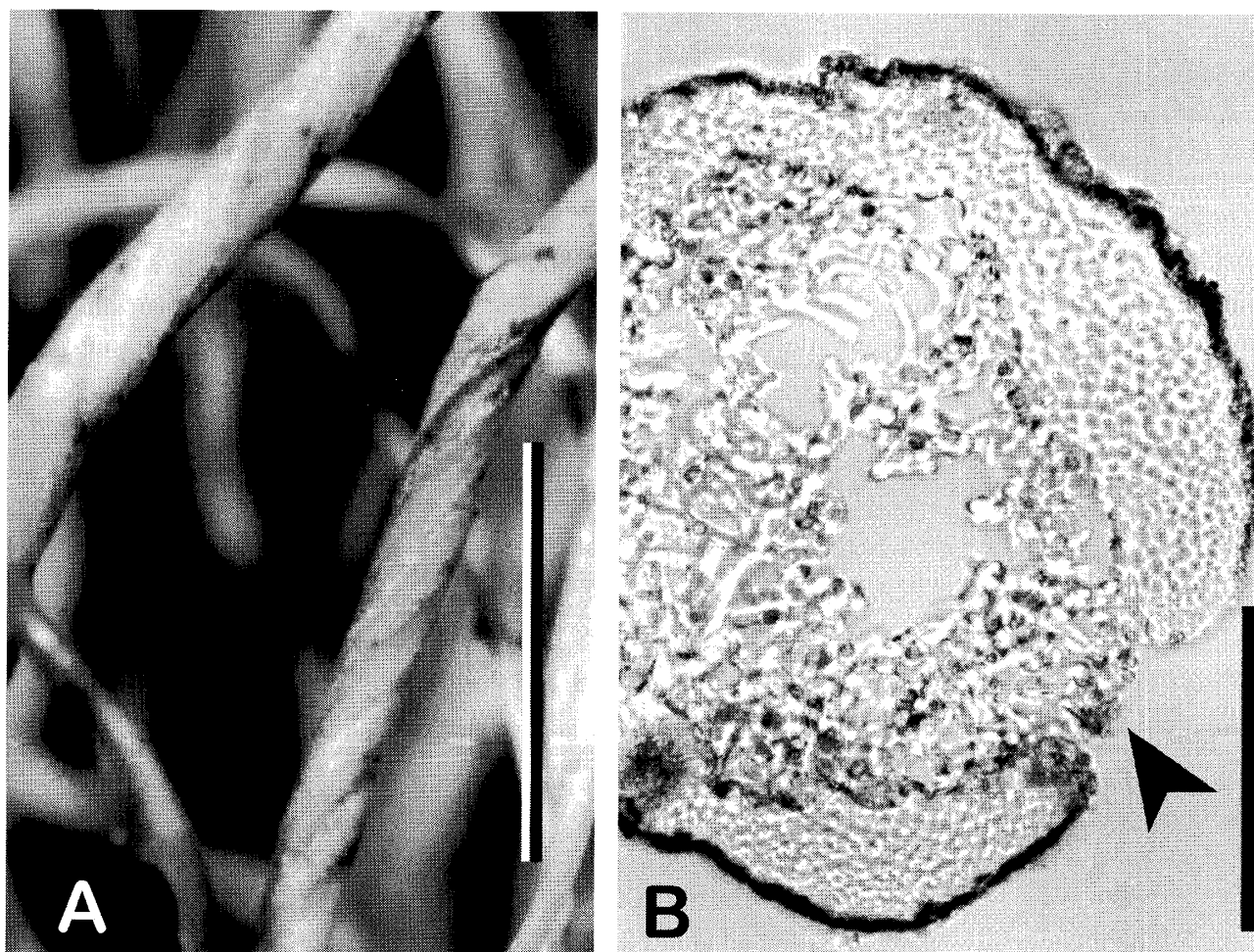


FIG. 2. *Bryoria hengduanensis*. A: branches showing pseudocyphellae twisted in long spirals. B: cross section of main branch, showing cortex discontinuous at pseudocyphella or sulca (arrow head). (A, B, from holotype. A, air-dried material; B, GAW preparation) Scale bars: A, 1mm; B, 100 $\mu$ m.

TABLE 1. Typical  $Rf \times 100$  values and representative  $R_t$  for compounds in *Bryoria hengduanensis*.

Compound	R <sub>f</sub> x 100/R <sub>f</sub> Norstictic acid, R <sub>f</sub> Atranorin*			H+ Color**	R <sub>t</sub> (min)
	A	B	C		
(from <i>Bryoria hengduanensis</i> )					
Usnic acid	74.5/43, 80	72/37, 78.5	80/26, 89	greenish gray	44.5
Fumarprotocetraric acid	3/43, 80	32.5/37, 78.5	8/26, 89	dark gray to black	33.6
Protocetraric acid	~3/43, 80	21.5/37, 78.5	~5/26, 89	dark gray to black	27.5
Confumarprotocetraric acid	~3/43, 80	14/37, 78.5	~1/26, 89	yellow	24.1
(from accompanying <i>Bryoria</i> sp.)					
Alectorialic acid	40/43, 80	~54/37, 78.5	29/26, 89	orange brown	31.5
Gyrophoric acid	25/43, 80	44/37, 78.5	~22/26, 89	yellowish to gray	36.7
Barbatolic acid	12/43, 80	54/37, 78.5	22/26, 89	yellow	40.1

\* $Rf$  values for some compounds that trail in a particular solvent system are concentration dependent, e.g. larger amounts of gyrophoric acid run higher in solvent A. Some compounds are obscured by one or more others, e.g. fumarprotocetraric acid is somewhat obscured by protocetraric and confumarprotocetraric acids in solvents A and C. The "~" before some  $Rf$  values indicates compounds obscured by one or more others in the samples tested.

\*\* "H + Color" is the appearance of the spot after visualization with 10%  $H_2SO_4$  and heating to ca. 100  $^{\circ}C$  for ca. 20 min.

TABLE 2. Analyses of some specimens of *Bryoria hengduanensis*.

Specimens	Analysis no.	compounds			
		US	FU	PR	CFU
Wang 93-13661	11962	+	M	tr	m
Wang 93-13673 (holotype)	11955	M	M	tr	tr
Wang 93-13674	11958	+	M	tr	tr
Wang 93-13675	11756a, c	M	M	tr	tr
Wang 96-16215	11961	+	M	tr	m
Wang 99-18507	11963	+	M	tr	m
Wang 00-19999	11956b	M	M	tr	tr
Wang 00-20018	11960	+	M	tr	tr
Wang 00-20309	11957	+	M	tr	m

Abbreviations of compound names: US = usnic acid; FU = fumarprotocetraric acid; PR = protocetraric acid; CFU = confumarprotocetraric acid

Proportions: M = major; m = minor; tr = trace; + = present, but the method of analysis did not allow an estimate of the proportion relative to other products.

*Distribution:* Hengduan Mountains in southern China (Sichuan and Yunnan).

*Habitat and ecology:* On trunks, branches, and twigs of *Abies georgei* and *Picea likiangensis* in coniferous forests, also on *Quercus pannosa*, usually associated with *Hypogymnia* sp. and sometimes *Usnea longissima*; 3000 - 4000 m elev.

*Remarks:* *Bryoria hengduanensis* is characterized by the following attributes: thallus hair-like, pendant, 3-5(-10cm) long, anisotomic-dichotomously branched towards the base, becoming isotomic-dichotomously branched towards the apices, black in the basal parts, pale brown towards the apices, shiny, lateral spinulose branches common, pseudocyphellae twisting in long spirals, soralia absent, medullary hyphae not ornamented, and usnic and fumarprotocetraric acids. It resembles *B. pseudocapillaris* Brodo & D. Hawksw., *B. spiralifera* Brodo & D. Hawksw., *B. tortuosa* Brodo & D. Hawksw. (1977), all from the Pacific North America, by its linear pseudocyphellae spiraling around branches. However, *B. pseudocapillaris* and *B. spiralifera* have white pseudocyphellae; and they differ in chemistry, having alectorialic and

barbatolic acids in the former and atranorin, norstictic and connorstictic acids in the latter (Brodo & Hawksworth 1977). *Bryoria tortuosa* differs by having slightly raised and unfissured pseudocyphellae, soredia (although rare), and the presence of vulpinic acid, accounting for the bright-yellow thallus (Brodo & Hawksworth 1977). *Bryoria hengduanensis* also resembles *Sulcaria badia* Brodo & D. Hawksw. (1977) from North America in having a brownish pendant thallus and linear pseudocyphellae spiraling around the main branches. However, *S. badia* differs in having a generally darker thallus ("very dull chestnut-brown to almost badius or yellowish brown in parts") and in chemistry by the presence of atranorin (K+ yellow) only (Brodo & Hawksworth 1977).

The generic placement of an alectorioid lichen lacking apothecia and ascospores is necessarily tentative. The diagnostic characters separating *Sulcaria* from *Bryoria* are yellow to brownish septate ascospores and a sulcate thallus (Brodo & Hawksworth 1977). Although the fissured pseudocyphellae (Fig. 2A) of the new species might be regarded as sulcae, but the species should not be placed in *Sulcaria* solely upon this character because pseudocyphellae are mechanically weak zones on the surface of the thallus that are easily broken into fissures or sulcae (Fig. 2B). Some genus-level tendencies are shown by the natural-product chemistry of the alectorioid lichens (summary: Esslinger 1989). The new species resembles *Alectoria* in having usnic acid, which is unknown in *Bryoria*, *Oropogon* and *Sulcaria*; but it resembles *Bryoria* and *Oropogon* in having fumarprotocetraric acid, which is unknown in *Alectoria* and *Sulcaria*. Until more evidence is available, we tentatively place this new species in *Bryoria* based on the presence of fumarprotocetraric acid as the major medullary product, the extreme hair-like habit of the thallus, and the medullary hyphae lacking ornamentation.

*Additional specimens examined (all paratypes in KUN unless stated):* CHINA. Yunnan Prov.

Zhongdian Co., Tian-chi Lake, 3900m elev., on *Abies georgei*, 27°35N, 99°48E, Aug. 1993, *Wang Li-song* 93-13661(KUN-L 13915), 93-13674 (KUN-L 13928), 93-13675 (KUN-L 13927; dup. in CBM); Wengshuei Village, Daxueshan Mt., 28°34N, 99°50E, 4000m elev., on *Picea* sp., 23 Aug. 2000, *Wang Li-song* 00-19999 (KUN-L 18232); on *Quercus pannosa*, 23 Aug. 2000, *Wang Li-song* 00-20018(KUN-L 18224); Gongshan Co., Binzhongluo to Tongdayakou, 98°41E, 28°05N, 3800m elev., on trunk of *Abies*, 21 Oct. 1999, *Wang Li-song* 99-18507(KUN-L 17298); Lijiang Co., Laojuenshan Mt., Jiushijiulongtan Lakes, Shimen, 99°43E, 26°37N, 3800m elev., on *Abies* sp., 13 Aug. 2000, *Wang Li-song* 00-20309(KUN-L 18260). Sichuan Prov. Luding Co., Gonggashan Mt., 3rd camp, near glacier, 101°30-102°10E, 29°20-30N, 3000m elev., on trunk of *Picea*, 30 Aug. 1996, *Wang Li-song* 96-16215 (KUN-L 17031).

We thank Dr. Bruce McCune, Oregon State University, for the loan of specimen and literature. Financial support was in part from the Goho International Fund for life Sciences.

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*Received April 7, 2001, accepted July 25, 2003*